# The MXT X-ray Telescope on board the SVOM mission

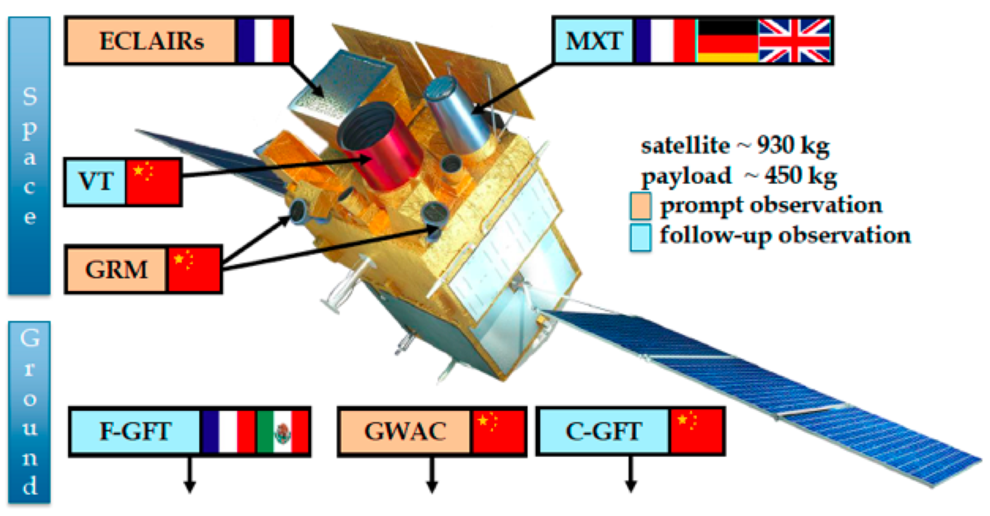
Diego Götz on behalf of the MXT collaboration
*CEA Saclay – Irfu/DAp – France*
*diego.gotz@cea.fr*

## *Abstract:*

The Microchannel X-ray Telescope is a small and compact focusing instrument that will be flown on the Sino-French mission SVOM (to be launched in 2021) dedicated to Gamma-Ray Bursts (GRBs) studies, time domain and multi-messenger astronomy. MXT is based on a narrow-field « Lobster Eye » optics made of micropores of 40 microns of side. The MXT field of view will be of about 1 square degree with a pretty uniform sensitivity. The focal plane of MXT will be built around a DUO pn CCD of 256x256 pixels of 75 microns, fully depleted over 450 microns, and cooled below -65° C. The MXT will be operated in the 0.2-10 keV energy range with the bulk of its effective area around between 1.0 and 2.0 keV due to the short focal length (1.15 m). MXT critical elements are being built and tested and a complete STM model ha recently been assembled for mechanical and environmental testing.

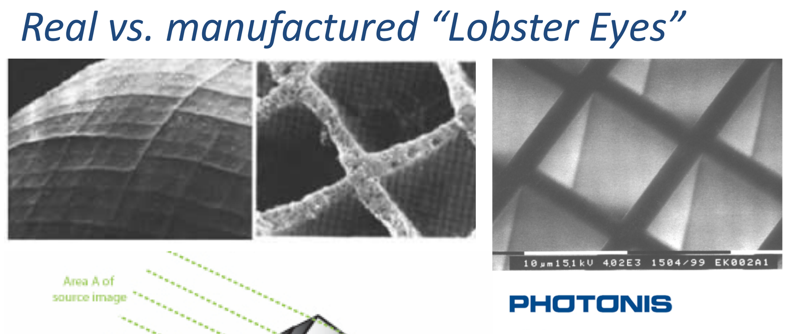
## The SVOM mission

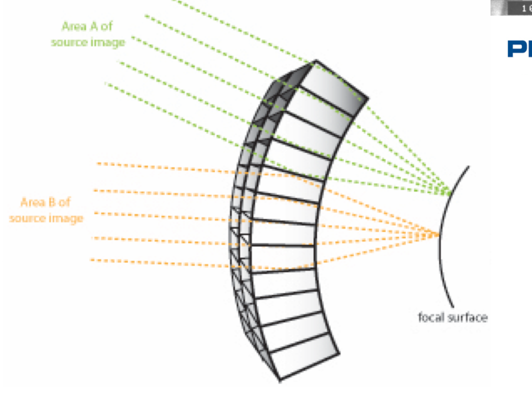
SVOM is a Sino-French Gamma-Ray Burst mission developed in cooperation by the French Space Space Agency (CNES), and the Chinese Academy of Sciences (CAS) (see B. Cordier and J. Wei talks). SVOM will be launched in 2021, and will carry two wide field instruments – the coded mask telescope ECLAIRs, providing the GRB triggers and intial localizations, and a non-imaging gamma-ray spectrometer GRM – and two narrow field instruments –- a visible telescope, VT, and the MXT X-ray telescope – that are pointed at the ECLAIRs error box after an autonomous platform slew to observe the GRB afterglows. SVOM Alerts will be transmitted to ground through a VHF Network and will be delivered to the Scientific Community with 30 seconds from detection in most of the cases.

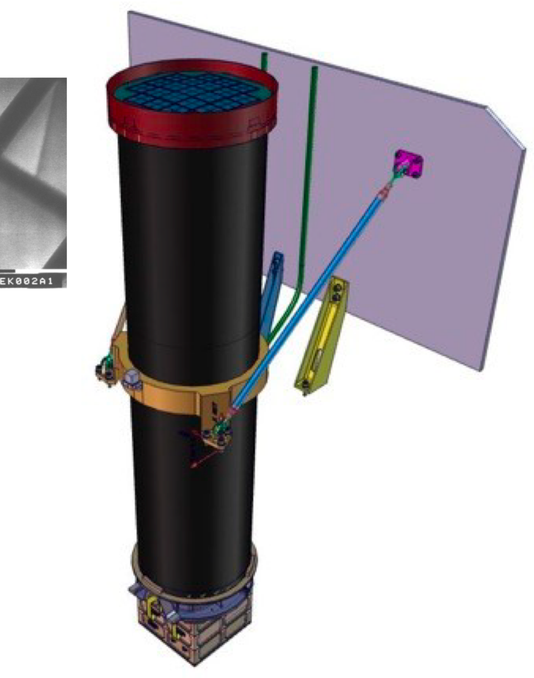



## The MXT Concept

*Real vs. manufactured "Lobster Eyes"*



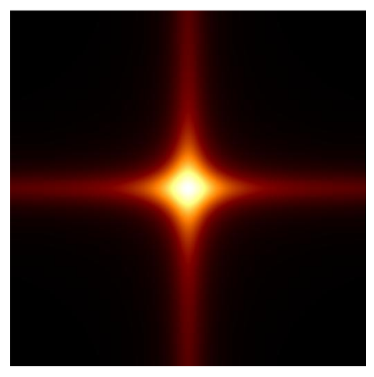


The Micro-channel X-ray Telescope (MXT) is a very light (~35 kg), and compact (~1.2 m) focusing X-ray telescope. Its large field of view (about 1 degree side) and its sensitivity below the mCrab level make of MXT a very good instrument to identify and precisely localize (below the arc minute) X-ray transients in non-crowded fields, and to study them in detail, thanks to its excellent spectral response (Götz+16). MXT is developed under CNES responsibility in close collaboration with CEA/Irfu, the University of Leicester, and the Max-Planck-Institut für Extraterrestrische Physik (MPE) and LAL. It will be composed by five main subsystems, an optical module (M-OP) based on square micro-pore optics (MPOs), a camera (M-CAM), a carbon fibre structure (M-ST), a data processing unit (M-DPU), and a radiator.

*"Lobster Eye" Optics Principle*

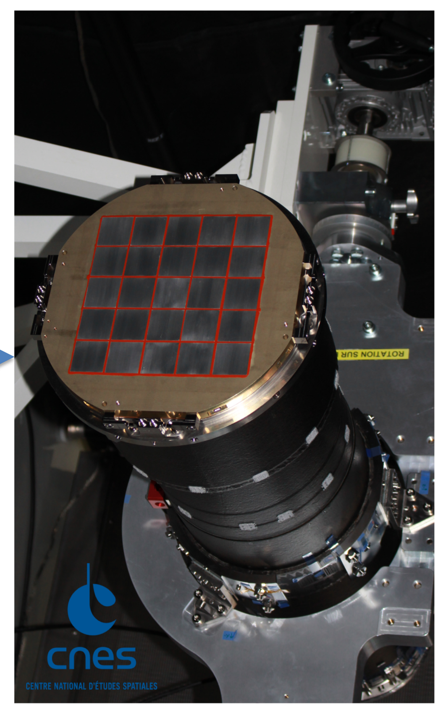
The optics of the MXT is based on a ``Lobster Eye'' grazing incidence geometry as first defined by Angel et al. (1979), and optimized for narrow-field use. The front of the optic will be coated with 70 nm of Al for thermal reasons and in order to reduce the optical load on the detector. The MPO PSF has a peculiar form, and is composed by a central spot and two cross arms: X-rays entering in the MPOs can either be reflected twice and focused in the central PSF spot, or reflected an odd number of times and focused in the PSF arms. For MXT about 65% of the incident X-ray flux is focussed in the central spot, 2x15% in the arms, and the rest in a diffuse patch. Thanks to the ``Lobster Eye'' geometry the vignetting is very low, of the order of 10--15% at the edge of the FOV.

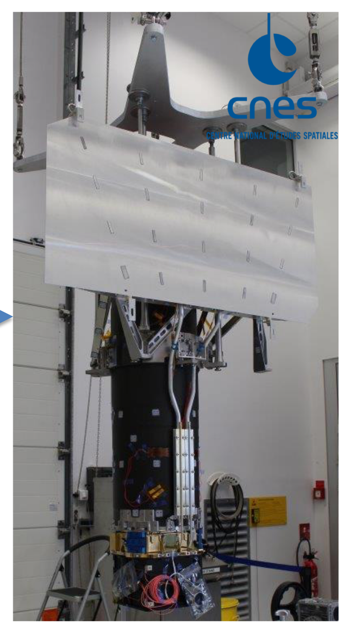
*Simulated PSF*



## MXT STM

*The complete MXT STM has been integrated in CNES and is ready to be delivered to China for integration and environmental testing at satellite level*

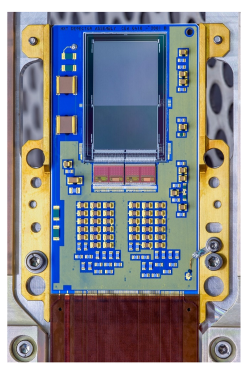


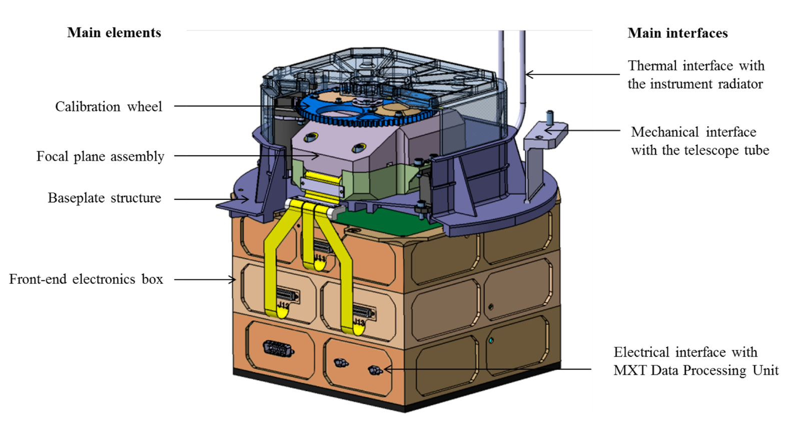

## The MXT Camera

The MXT camera design is based on a pnCCD developed by the MPE/HLL for the DUO Mission (Meidinger at al. 2006), and is a small scale version of the eROSITA detectors.

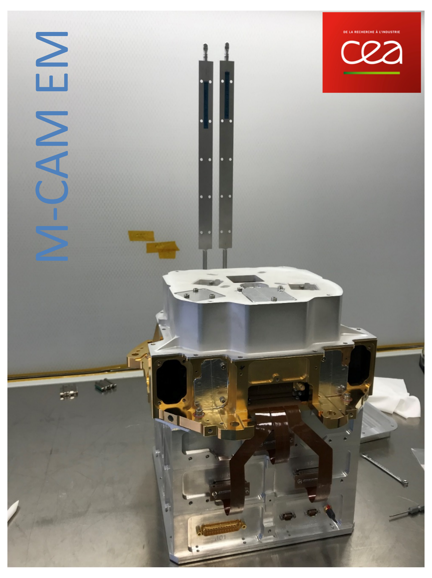
The pnCCD has an active area of 256x256 pixels of 75 microns, and a reduced frame store area. The CCD is read out in parallel by two CAMEX ASICs, and has an excellent low-energy response coupled to a very low read-out noise, and intrinsic radiation hardness .



FPA EM



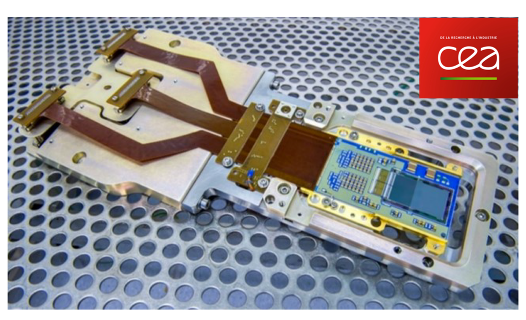

M-CAM EM

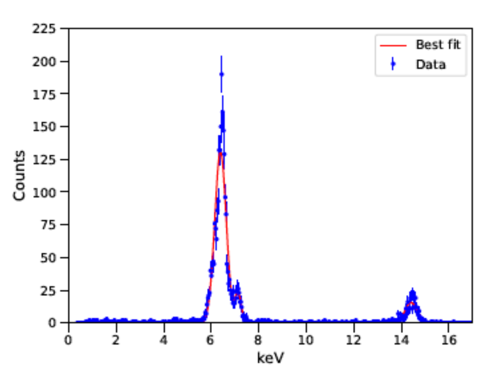


M-CAM Electrical (EM) and Structural and Thermal (STM) Models have been realized in 2018 and used for environmental testing.

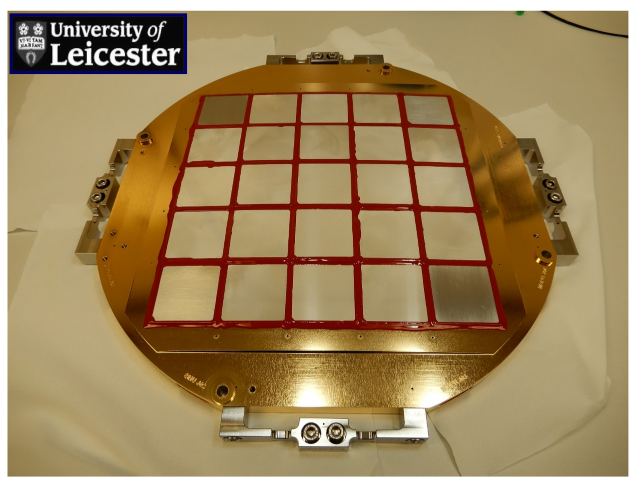
The M-CAM focal plane array (FPA) EM has also been realized in 2018, and it has allowed to test the readout electronics prototype. A first spectrum using a $^{57}$Co radioactive source could be obtained, see Ceraudo+19.

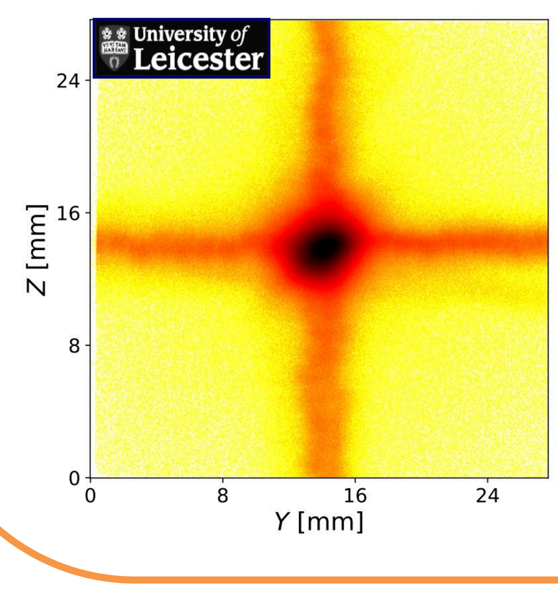
FPA EM





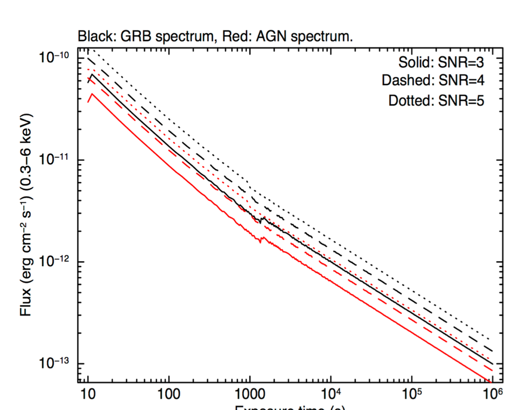

## The MXT Optical Module



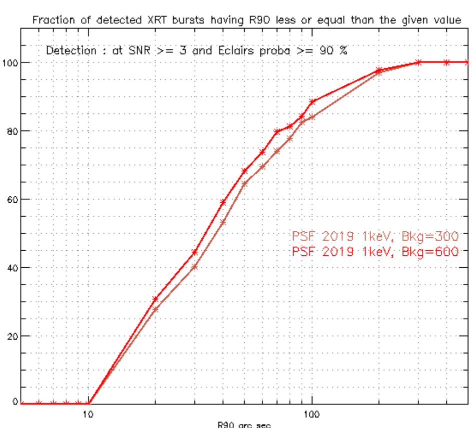

The M-OP Qualification Model (QM) has been assembled at the University of Leicester and is being tested in a long beamline X-ray test facility. Measurements at Al-K (1.49 keV) on individual MPOs have been performed and the *first image of a fully populated optics* has been obtained. The derived information will be used to optimize the design of the FM optic, and to improve the physical understanding of these peculiar type of optics. Detailed measurements will be made during summer 2019 at MPE PANTER test facility in Munich in order to derive further information about the optical properties at different energies and off-axis.

## MXT Simulated Performance

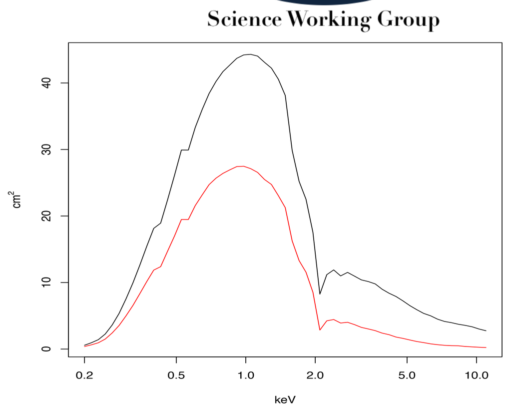



Sensitivity

The XRT afterglow database has been folded through the MXT response in order to estimate the typical localisation error after 5 and 10 minutes of observation. 80% of the GRBs have error boxes > 1 arc min after 10 minutes of observation.



GRB Localization



Expected Effective area (red: central spot, black: total)

### References:

D. Götz et al. SPIE, 99054L (2016)
N. Meidinger, et al., Nucl. Instr. & Meth. A 568, pp.141-148 (2006)
F. Ceraudo, et al. IEEE in press (2019)

## Conclusions

The MXT instrument is currently in phase C and its sub-system Qualification Models (QM) are being realized. The critical performances are being tested and the Flight Model is planned to be integrated at CNES in 2020 to be delivered to SECM early 2021. Complete end to end tests will be performed at PANTER facility end 2019 for the complete telescope QM and end 2020 for the telescope flight model.